

AD 736941

TECHNICAL REPORT NO. 72-1

OPERATION OF THE  
TONTON FOREST SEISMOLOGICAL OBSERVATORY  
Quarterly Report No. 2, Project VI/2704  
Contract F33657-72-C-0013  
1 October through 31 December 1971

Sponsored by

Advanced Research Projects Agency  
Nuclear Test Detection Office  
ARPA Order No. 1714

Availability

Qualified users may request copies  
of this document from:

Defense Documentation Center  
Cameron Station  
Alexandria, Virginia 22314

Neither the Advanced Research Projects Agency nor the Air Force Technical Applications Center will be responsible for information contained herein which has been supplied by other organizations or contractors, and this document is subject to later revisions as may be necessary. The views and conclusions presented are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, the Air Force Technical Applications Center, or the U. S. Government.

Approved for Public Release.  
Distribution Unlimited.

Reproduced by  
**NATIONAL TECHNICAL  
INFORMATION SERVICE**  
Springfield, Va. 22151

TELEDYNE GEOTECH  
3401 Shiloh Road  
Garland, Texas

15 January 1972

**BEST  
AVAILABLE COPY**

UNCLASSIFIED

Security Classification

## DOCUMENT CONTROL DATA - R &amp; D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Teledyne Geotech  
3401 Shiloh Road  
Garland, Texas 75041

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

Operation of Tonto Forest Seismological Observatory  
Quarterly Report No. 2, Project VT/2704, 1 October through 31 December 1971

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Goetech Staff

6. REPORT DATE

15 January 1972

7a. TOTAL NO. OF PAGES

21

7b. NO. OF REFS

8a. CONTRACT OR GRANT NO.

F33657-72-C-0013

b. PROJECT NO.

VELA T/2704

c. ARPA Order No. 1714

d. ARPA Program Code No. 1F10

8a. ORIGINATOR'S REPORT NUMBER(S)

TR 72-1

8b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

11. SUPPLEMENTARY NOTES

Approved for Public Release  
Distribution Unlimited.

12. SPONSORING MILITARY ACTIVITY

Advanced Research Projects Agency  
Nuclear Test Detection Office  
Washington, D. C. 20333

13. ABSTRACT

This is a report of the work accomplished on Project VT/2704 from 1 October through 31 December 1971. It describes the operation, evaluation, and improvement of the Tonto Forest Seismological Observatory (TFSO) located near Payson, Arizona, research and test functions carried out at the TFSO, and research and development tasks performed by the Garland, Texas, staff using TFSO data.

UNCLASSIFIED

Security Classification

14	KEY WORDS	LINK A		LINK B		LINK C	
		ROLE	WT	ROLE	WT	ROLE	WT
	Long-Period Array						
	Short-Period Array						
	Seismograph Operating Parameters						
	Multichannel Filter						

UNCLASSIFIED

Security Classification

IDENTIFICATION

AFTAC Project No:	VELA T/2704
Project Title:	Tonto Forest Seismological Observatory
ARPA Order No:	1714
ARPA Program Code No:	1F10
Name of Contractor:	Teledyne Industries, Inc. Geotech Division Garland, Texas
Contract No:	F33657-72-C-0013
Effective Date of Contract:	1 July 1971
Amount of Contract:	\$150,000
Contract Expiration Date:	30 June 1972
Program Manager:	E. B. Leichliter 271-2561, ext. 222

## CONTENTS

	<u>Page</u>
ABSTRACT	
1. INTRODUCTION	1
1.1 Authority	1
1.2 History	1
2. OPERATION OF TFSO	1
2.1 General	1
2.2 Standard seismograph of operating parameters	3
2.3 Data channel assignments	3
2.4 Completion and shipment of data	3
2.5 Quality control	3
2.5.1 Quality control of 16-mm film seismograms	3
2.5.2 Quality control of analog FM magnetic-tape seismograms	6
2.5.3 Quality control of ASDAS magnetic-tape seismograms	6
2.5.4 Quality control of DGRDAS magnetic-tape seismograms	7
2.6 Inspections	7
2.7 Emergency power generator	7
2.8 Facility maintenance	7
2.9 Weather	8
2.10 Spiral-four cables	8
2.11 Relocation of LPs	8
3. INSTRUMENT EVALUATION	9
3.1 Long-period triaxial system	9
3.2 Short-period five-element station	9
3.3 Digital gain-ranging data acquisition system	9
3.4 Astrodata seismic data acquisition system	9
3.5 Multichannel filter	9
3.6 Gravity feed chemical supply system	10
3.7 Extended long-period seismograph	10
3.8 Short-period, 37-element array	10
3.9 Long-period array	11
3.10 Quartz accelerometer	11
4. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS	11
4.1 Assistance provided	11
4.2 Visitors	11

APPENDIX - Statement of work to be done

## ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	Location of TFSO	2
2	Normalized response characteristics of standard seismographs at TFSO	5

.....

## TABLES

<u>Table</u>		<u>Page</u>
1	Operating parameters and tolerances of standard seismographs at TFSO	4

# ABSTRACT

This is a report of the work accomplished on Project VT/2704 from 1 October through 31 December 1971. It describes the operation, evaluation, and improvement of the Tonto Forest Seismological Observatory (TFSO) located near Payson, Arizona, research and test functions carried out at the TFSO, and research and development tasks performed by the Garland, Texas, staff using TFSO data.



OPERATION OF THE  
TONTA FOREST SEISMOLOGICAL OBSERVATORY  
Quarterly Report No. 2, Project VT/2704  
Contract F33657-72-C-0013  
1 October through 31 December 1971

1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Test Detection Office, and was monitored by the Air Force Technical Applications Center (AFTAC) under Contract F33657-72-C-0013. The effective date of the contract is 1 July 1971; the Statement of Work for Project VT/2704 is included in the appendix to this report.

1.2 HISTORY

The Tonto Forest Seismological Observatory (TFSO) was constructed by the United States Corps of Engineers in 1963. TFSO was designed to record seismic events and to be used as a laboratory for testing, comparing, and evaluating advanced seismograph equipment and seismometric recording techniques. The instrumentation was assembled, installed, and operated until 30 April 1965 by the Earth Sciences Division of Teledyne Industries under Contract AF 33(657)-7747. On 1 May 1965, Geotech assumed the responsibility of operating TFSO. The location of TFSO is shown in figure 1.

2. OPERATION OF TFSO

2.1 GENERAL

Data are recorded continuously at the TFSO for 24 hours each day of the week. The instrumentation that accomplishes this, and other instrumentation that is used for special tests, have been operated and maintained during this report period by a staff of four technical people. Administrative work is handled by one half-time person. All work is being accomplished during a "normal shift" from 8:00 a.m. to 5:00 p.m., and a "late shift" from 9:30 a.m. to 6:00 p.m. The normal work shift is worked each Monday through Friday except holidays and is considered the regular work day by all personnel. The late shift is worked every day including Saturdays, Sundays, and holidays, and is staffed by one man on a rotational basis.

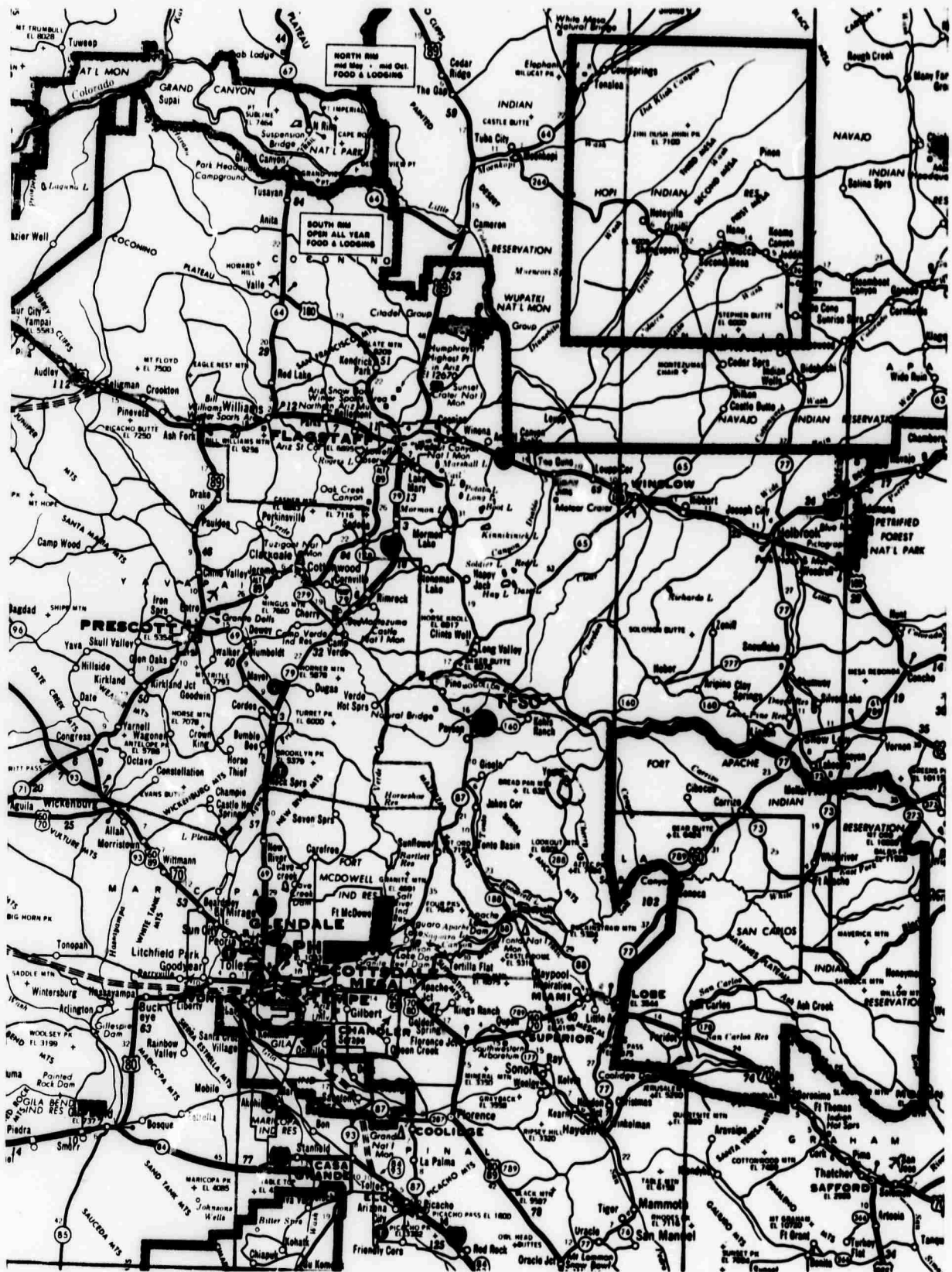


Figure 1. Location of TFSO

## 2.2 STANDARD SEISMOGRAPH OF OPERATING PARAMETERS

The operating parameters and tolerances for the TFSO standard seismographs are shown in table 1. Frequency response tests are made routinely and parameters are checked and reset to maintain the specified tolerances.

Normalized response characteristics of TFSO standard seismographs are shown in figure 2.

## 2.3 DATA CHANNEL ASSIGNMENTS

Each data format recorded at TFSO is assigned a Data Group number. When a data format is changed, a new Data Group number is assigned. Data Format Change Notices reporting changes in channel assignments were submitted to the Project Officer and to frequent users of the TFSO data during this report period.

## 2.4 COMPLETION AND SHIPMENT OF DATA

Six analog FM magnetic-tape units are used to record data for the VELA Seismological Center (NYV). Before 1 March, tapes from these units had been sent weekly to our Garland, Texas, laboratory for quality control and had been shipped from Garland to SDL about 15 days after the end of the month in which they were recorded. Since 1 March, all FM tapes for six days were sent directly to SDL each week. Only tapes for one day were sent to Garland for quality control inspection and forwarding to SDL.

All ASDAS tapes, except two per week that were sent to Garland for quality control, were held at the observatory for a period of about 8 weeks and then were recycled if not requested by a data user.

All Develocorder (16-mm film) seismograms, except quality control copies, were routinely shipped to SDL. One seismogram for each Develocorder was sent each week to our Garland, Texas, laboratory for quality control, then forwarded to SDL.

Copies of calibration and operational logs accompanied all data shipments.

## 2.5 QUALITY CONTROL

### 2.5.1 Quality Control of 16-mm Film Seismograms

Quality control checks of randomly-selected 16-mm film seismograms from Data Trunks 2, 4, and 8 and the associated logs were made in Garland. Items that were routinely checked by the quality control analyst include:

- a. Film boxes - neatness and completeness of box markings;
- b. Develocorder logs - completeness, accuracy, and legibility of logs;

Table 1. Operating parameters and tolerances of standard seismographs at TFSO

Seismograph			Operating parameters and tolerances					Filter settings		
System	Comp	Type	Model	Ts	λs	Tg	λg	Model	Bandpass at 3 dB cutoff (sec)	Cutoff rate at SP side (dB/oct)
Sp <sup>a</sup>	Z	Johnson-Matheson	6480	1.25 ±2%	0.54 ±5%	---	---	2888-1	0.2 - 1.0	6
Sp <sup>b</sup>	Z	Johnson-Matheson	6480	1.25 ±2%	0.54 ±5%	0.33 ±5%	0.65 ±5%	6824-1	0.1 - 100	12
Sp <sup>b</sup>	H	Johnson-Matheson	7515	1.25 ±2%	0.54 ±5%	0.33 ±5%	0.65 ±5%	6824-1	0.1 - 100	12
SP	Z	Benioff	1051	1.0 ±2%	1.0 ±5%	0.2 ±5%	1.0 ±5%	6824-1	0.1 - 100	12
SP	H	Benioff	1101	1.0 ±2%	1.0 ±5%	0.2 ±5%	1.0 ±5%	6824-1	0.1 - 100	12
SP	Z	UA Benioff	1051	1.0 ±2%	1.0 ±5%	0.75 ±5%	1.0 ±5%	---	---	---
BB	Z	Press-Ewing	SV-282	12.5 ±5%	0.45 ±5%	0.64 ±5%	9.0 ±5%	6824-7	0.05- 100	12
LP	Z	Geotech	7505A	20.0 ±5%	0.77	---	---	30024	80 - 300	6
LP	H	Geotech	8700C	20.0 ±5%	0.77	---	---	30024	80 - 300	6

KEY

SP Short period  
IB Intermediate band  
LP Long period  
UA Unamplified (i.e., earth powered)  
BB Broad band

Ts Seismometer free period (sec)  
Tg Galvanometer free period (sec)  
λs Seismometer damping constant  
λg Galvanometer damping constant

<sup>a</sup>37-element hexagonal array

<sup>b</sup>Linear array and 3 comp

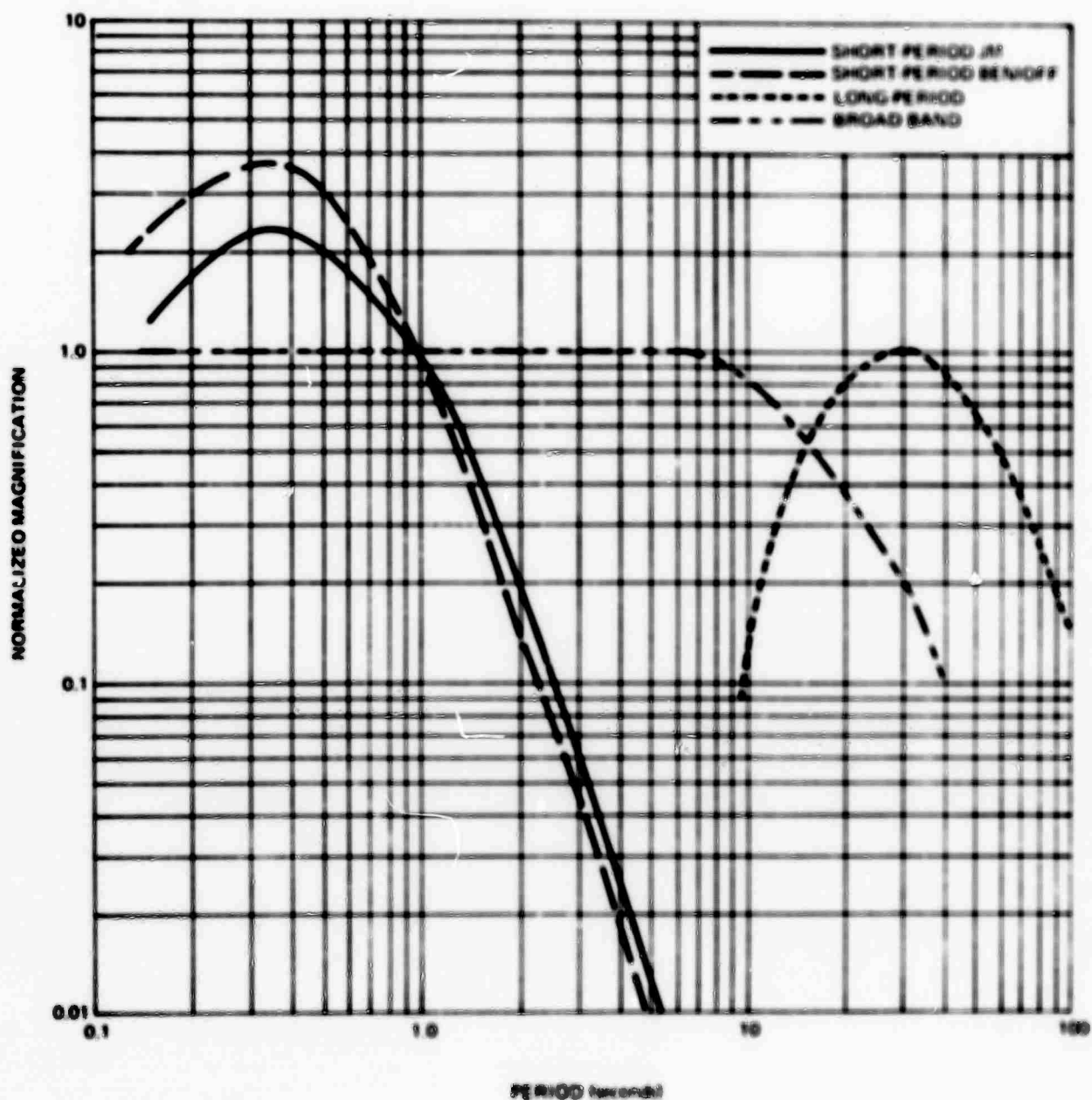


Figure 2. Normalized response characteristics of standard seismographs at 1150

c. Film -

(1) Quality of the overall appearance of the record (for example, trace spacing and trace intensity);

(2) Quality of film processing.

d. Results of these evaluations were sent to the observatory for their review and comment.

2.3.2 Quality Control of Analog FM Magnetic-Tape Seismograms

Each week, quality control checks of three randomly-selected magnetic-tape seismograms are made in Garland and at TFSO to assure the recordings meet specified standards. The following items are checked:

- a. Tape and box labeling;
- b. Accuracy, completeness, and neatness of logs;
- c. Adequate documentation of logs by voice comments on tape where applicable;
- d. Seismograph polarity;
- e. Level of the microseismic background noise;
- f. Level of calibration signals;
- g. Relative phase shift between array seismographs;
- h. Level of system noise;
- i. Oscillator alignment;
- j. Quality of recorded WY signal where applicable;
- k. Time-pulse carrier;
- l. Binary-coded digital time marks.

2.3.3 Quality Control of ASHS Magnetic-Tape Seismograms

Quality control checks of ASHS tapes are made routinely. At present, one tape from each of the two transports is checked weekly for the following items:

- a. Neatness and accuracy of the associated logs;
- b. Polarity errors;
- c. Recording level of each channel;

- d. Fidelity of reproduction;
- e. Presence of header record and correct record length;
- f. Tape parity errors;
- g. Timing information.

#### **2.5.4 Quality Control of DGRNAS Magnetic-Tape Seismograms**

Quality control checks of DGRNAS tapes are made routinely. At present, one tape is checked each week for all items listed under section 2.5.3 and, in addition, for the following items:

- a. Field transmission parity errors;
- b. Central digital system parity errors;
- c. Gain code errors.

#### **2.6 INSPECTIONS**

A security inspection was conducted on 27 October by Mr. Ken Osbolt, Industrial Security, Phoenix, Arizona. All phases of the TFSO security program were found to be in good order.

#### **2.7 EMERGENCY POWER GENERATOR**

The 100 kW diesel-powered generator was operated for a total of 1 hour and 48 minutes under full load conditions. The storage batteries that furnish power to start the diesel engine failed during tests on 8 November and were replaced.

#### **2.8 FACILITY MAINTENANCE**

The TFSO facilities were maintained in accordance with sound industrial practices throughout the report period. This work included pest extermination, fire extinguisher inspection, work area cleaning, and lubrication and cleaning of the heating and air conditioning equipment.

## 2.9 WEATHER

Lightning, observed in the array area on 4 days during this quarter, caused no known damage to TFSO instrumentation. The six lightning-caused failures noted in section 2.10 are believed to have resulted from earlier lightning storms. However, heavy precipitation adversely affected field instrument performance. Rain or snow, falling during 23 days, introduced moisture into many field circuits, causing them to become noisy.

## 2.10 SPIRAL-FOUR CABLES

There were 76 spiral-4 cable assembly failures during October, November, and December 1971. Four were caused by vandalism, 10 by cable deterioration, 15 by moisture, 23 by road graders, 6 by lightning, 1 by gnawing animals, and 17 by pulpwood cutters. These were repaired by replacing 43 quarter-mile sections of cable, making 21 splices, rebuilding 6 splice boxes, and cleaning 6 hocks.

Two miles of cable to the 222 site were found damaged in numerous places by heavy equipment used by contractors cutting pulpwood for Southwest Forest Industries. As this was the second time that TFSO cable was damaged by these pulpwood cutters, a formal complaint was registered with Southwest Forest Industries.

Cables to ten other short-period array sites were also damaged by heavy equipment, some in numerous places within a quarter-mile section. All this damage was found near roads and jeep trails recently repaired and upgraded by the Tonto Forest National Engineer Service. Meetings were held with representatives of this organization to discuss the problem and to make plans for the coordination of activities to minimize or prevent further cable damage.

## 2.11 RELOCATION OF LP6

Engineering Change Proposal No. 1, which describes the work required to relocate field site LP6 and indicates the need for this change, was submitted on 22 October. On 27 December 1971, we received a request from ASD to submit a proposal breaking down the costs in greater detail than in the original engineering change proposal. Our response is being prepared and will be submitted as requested.

In response to the 17 November letter from the Phoenix office of the United States Forest Service to the Project Office, we are submitting a new set of plans for the 700 feet of road into the proposed relocation site.



### **3. INSTRUMENT EVALUATION**

#### **3.1 LONG-PERIOD TRIAXIAL SYSTEM**

Recording of data from the long-period triaxial system was stopped on 14 October, and power to instrumentation in that system was disconnected.

#### **3.2 SHORT-PERIOD FIVE-ELEMENT STATION**

Recording of data from the short-period five-element station was stopped on 14 October, and the radio telemetry and other Remote Operating Facility (ROF) equipment was removed from the field. All five borehole seismometers, their remote terminal units, and interconnecting cables were left as originally installed.

#### **3.3 DIGITAL GAIN-RANGING DATA ACQUISITION SYSTEM**

The digital gain-ranging data acquisition system was operated continuously except for record change and routine maintenance during October, November, and December. On 16 December, the start-up procedure was modified to improve transport starting reliability and to eliminate the generation of a word length error flag during start-up.

#### **3.4 ASTRODATA SEISMIC DATA ACQUISITION SYSTEM**

The Astrodata seismic data acquisition system was operated routinely throughout the report period. Maintenance to the system included routine cleaning, tape head realignment, drag brake repairs, and the replacement of brake pins, a vacuum motor, a fuse, and a read card.

#### **3.5 MULTICHANNEL FILTER**

The multichannel filter (MCF) was not used from 17 August to 17 November because many of the short-period array channels that furnish data to the MCF were noisy or completely inoperative. Since 17 November, data from Z1 through Z19 have been processed and recorded using the following format.

### ISCF FORMAT

17 November 1971 through present

<u>Channel Identification</u>	<u>Azimuth from TPSO</u>	<u>Distance from TPSO</u>	<u>Approximate location</u>	<u>Apparent velocity (km/sec)</u>
BS0	0°	70	Noraya Zeniya	18
BS1	315°	70	Kurile Islands	18
BS2	270°	70	Marshall Islands	18
BS3	225°	70	Cook Islands	18
BS4	180°	70	Easter Islands	18
BS5	135°	70	Arica, Chile	18
BS6	90°	70	Cape Verde Basin	18
BS7	45°	70	Portugal	18
BS8	Any	180	East Crozet Basin	-
BS9	315°	70	Kurile Islands	18
Fisher - Beamed for 315° azimuth 70° distance				
Fisher threshold set to 240g - 20610				

The ISCF was put into operation without its RFI filter, which was found defective and was returned to its manufacturer for repairs.

### 3.6 GRAVITY FEED CHEMICAL SUPPLY SYSTEM

The gravity-feed chemical supply systems used in the long-period Develocorders operated without failure, but those used to supply the fixing solution to the short-period Develocorders failed with increasing frequency as the average outdoor temperature dropped. Attempts to solve this problem by cleaning the system, replacing control valves, and heating the control valve, have not been successful in restoring reliable operation. It is planned to reinstall peristaltic pumps in all but 1 or 2 of the short-period Develocorders until this problem can be solved. Good film quality was maintained during this report period by manually fixing and washing films from Develocorders whose chemical supply systems failed during unmanned, nighttime operation.

### 3.7 EXTENDED LONG-PERIOD SEISMOGRAPH

The extended long-period seismograph, ZLSP, was operated at a magnification of 140K throughout the report period.

### 3.8 SHORT-PERIOD, 37-ELEMENT ARRAY

Recording of short-period array channels 221 through 237 was discontinued on 15 October because only one of these channels was operative.

### **3.9 LONG-PERIOD ARRAY**

The 2-wire telephone circuit to the LP2 site was changed to a 4-wire circuit by Mountain Bell. The new circuit, installed at no charge, will permit transmission of both data and calibration data via telephone circuits. Before the change, calibrations were transmitted to LP2 via the 222 calibration cable, which is not presently in service.

### **3.10 QUARTZ ACCELEROMETER**

On 11 December a preliminary plan for the evaluation of the Block and Moore quartz accelerometer was submitted to the Project Office. A suggested time schedule and budgetary information were included in the plan.

## **4. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS**

### **4.1 ASSISTANCE PROVIDED**

Event information was furnished to Mr. M. Person, Oceanic Survey, and to Mr. John Hendricks, Astrogeological Center, Flagstaff, Arizona.

### **4.2 VISITORS**

Mr. Ed Barkman, of the United States Forest Service, and Messrs. William A. Sauck and Robert F. Lundin, student geologists from the Arizona State University, visited TFSO on 23 December and were conducted on a tour of the facilities.

APPENDIX to TECHNICAL REPORT NO. 72-1

STATEMENT OF WORK TO BE DONE

27 JAN 1971

STATEMENT OF WORK TO BE DONE

(AFTAC Project Authorization No. VELA T/2704/B/ASD)

1. Objectives. The Tonto Forest Seismological Observatory (TFSO) is unique in its low level of background seismic noise and in its capability as a research center, being equipped with various film, paper and analog and digital recorders, a shake table, a large walk-in vault for instrument evaluation, and assorted test and measurement equipment. The purpose of this project is to operate this observatory as a source of high-quality seismological data for use in Government-sponsored research projects, to use the TFSO as a field test site for evaluation of new seismological instrumentation and procedures, and to support other research projects as identified by the project officer. This project should require a manning level of approximately five man-years.

2. Tasks.

a. Operation.

(1) Continue operating the TFSO according to established procedures (Standard Operating Procedures for TFSO, 1 Nov 1970), providing recorded data to the Government. Special data requirements anticipated will include, but not be limited to, recording signals from special events at the Nevada Test Site and supplying beam-formed or multichannel filtered data for use in evaluation of the effectiveness of the ARPA long-period arrays: Montana Large Aperture Seismic Array, Alaskan Long-Period Array, and Norwegian Seismic Array.

(2) Quality control the data acquisition systems and evaluate the seismic data recorded to determine optimum operating characteristics and perform research to improve operating parameters to provide the most effective observatory practicable. Major reconfigurations in equipment, those requiring more than 48 hours to remove, are subject to prior approval by the project officer.

(3) Provide use of observatory facilities and seismological data to requesting organizations and individuals as identified by the project officer.

(4) Maintain, repair, protect, and preserve the facilities of TFSO in good physical condition in accordance with sound industrial practice.

b. Instrument Evaluation.

(1) Evaluate the performance characteristics of experimental equipment identified by the project officer. This work involves investigation of such components as seismometers and amplifiers, combinations of components such as are involved in lightning protection

REPRODUCTION

Atch 2

-1-

Preceding page blank

TR 72-1, app

improvement, and altered modes of operation such as radio transmission of data. These necessary investigations will be initiated only after advances in the state-of-the-art identify problems needing work. At present, the following areas for possible investigation are:

(a) Long-term field testing of a new version of the Geotech 23900 long-period seismometer incorporating an internal feedback system.

(b) Test and evaluation of a horizontal short-period array according to existing general operating procedures contained in Standard Operating Procedures for TFSO, 1 Nov 1970.

(c) Evaluation of an intermediate-frequency range system to be provided by the Government for recording of reflected body phases.

(d) Evaluation of special on-line signal detection algorithms.

(2) Maintain the equipment necessary to perform the above mentioned evaluations, including the shake table, signal conditioning and recording equipment, test and calibration instrumentation, and film viewers.

c. Upon identification and prior to the disposition of any equipment determined to be excess to the needs of the project, the contractor shall notify the project officer.